RADIO *Shop* MANUAL

MODERN RADIO SERVICING

ERM-2

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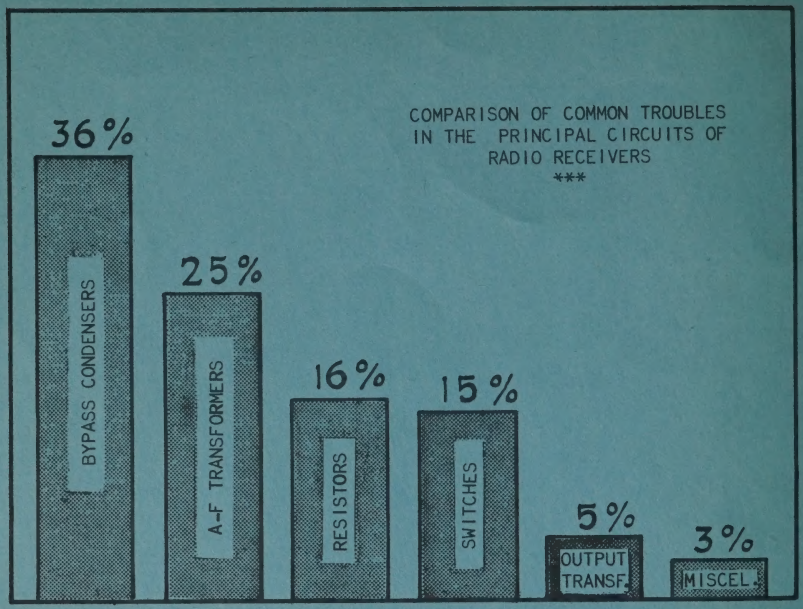
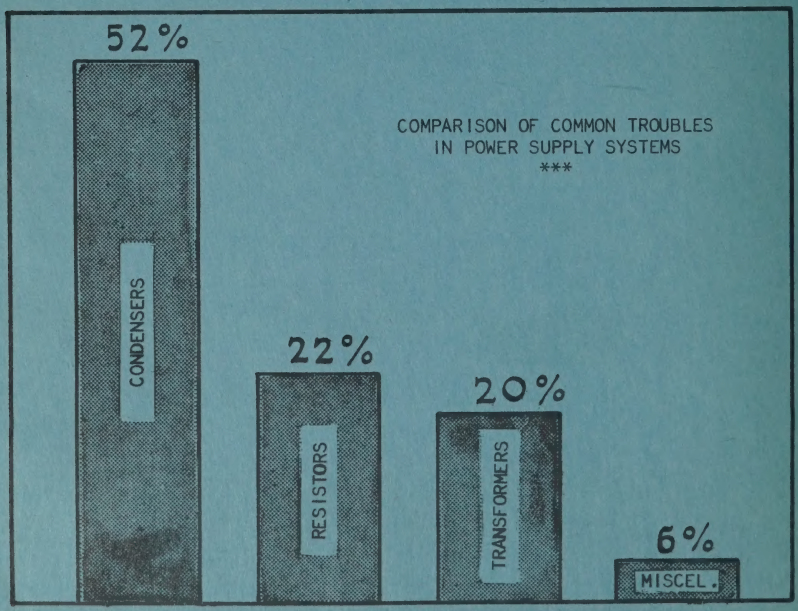

COMPARISON OF COMMON TROUBLES
IN THE PRINCIPAL CIRCUITS OF
RADIO RECEIVERS
***
36%
BYPASS CONDENSERS
25%
A-F TRANSFORMERS
16%
RESISTORS
15%
SWITCHES
5%
OUTPUT TRANSF.
3%
MISCEL.


COMPARISON OF COMMON TROUBLES
IN POWER SUPPLY SYSTEMS
***
52%
CONDENSERS
22%
RESISTORS
20%
TRANSFORMERS
6%
MISCEL.

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4000 SOUTH FIGUEROA STREET
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MODERN RADIO SERVICING

Besides being a very interesting branch of the industry, radio servicing constitutes a very effective means for increasing your income. However, to become a successful service technician it is necessary that you acquire the ability to recognize radio troubles and to correct them efficiently.

One frequently encounters men in the field who, although equipped with a thorough knowledge of radio theory, nevertheless find themselves at a complete loss when confronted with radio service problems -- this being due chiefly to the fact that they lack the practical knowledge and experience which is so essential in order to do this type of work efficiently.

Our course has been planned so that you will not be confronted with the same difficulties as experienced by these half-trained men. We accomplish this in the following manner:

Your regular lessons contain all of the technical information that is required to provide you with a thorough knowledge of radio theory, while the Shop Manuals and Experimental Projects outlined in the special Experiment Lessons furnish you with the practical service instruction and experience.

MUCH DEPENDS UPON YOUR INITIATIVE AND PERSEVERANCE

This complete practical training, together with a little initiative on your part, is all that is necessary to start you on the road to success in radio servicing. You must remember, however, that your ultimate success depends much upon your INITIATIVE and PERSEVERANCE -- which in a great measure is responsible for success and prosperity in any vocation.

The radio serviceman occupies the same position in the radio industry as does the doctor in the field of medicine. Such being the case, he is faced with practically the same problems regarding advancement in his chosen field as is the young medical graduate.

Every year, thousands of medical students are graduated from the many universities through

FIG. 1
TUBES ARE A COMMON CAUSE OF TROUBLE

out the world, each with practically the same amount of knowledge and, perhaps, the same opportunities for making good. However, upon analyzing case histories of a group of these same students several years later, we find that the great majority has not advanced beyond the stage of the small-town doctor; that others occupy more or less satisfactory positions in city clinics and laboratories, and that very few have through their own initiative and perseverance attained success to the extent where they have become known throughout medical circles as specialists or scientists.

As you will see from the above, the only difference between the prosperous scientist or research worker and the small-town doctor is that the former had the foresight to work continually toward a predetermined goal, whereas the latter was satisfied with what he could learn at the university.

A similar condition exists in the radio industry. Many so-called practical radio men spend years of untiring effort in repairing radios without advancing themselves beyond the ordinary "repairman stage." However, we are proud of the fact that a great many of our graduates are the type of men who had the foresight and ambition to continue studying after graduation, ultimately attaining responsible positions in the industry. We are depending on you to do likewise -- whether it be in the field of servicing or in any one of the other many highly specialized divisions of the industry.

LEARN TO THINK -- THINK BEFORE YOU ACT

To become a successful service technician, you must learn to think before you act, and to analyze all symptoms carefully before formulating your conclusion as to what is wrong. A few minutes of conscientious meditation and deduction will generally save you long hours of guess-work.

COMMON CAUSES FOR RECEIVER TROUBLES

The efficient operation of the modern receiver is made possible by the use of sensitive circuits which are adjusted accurately by laboratory equipment. Consequently, if one of its components develops a defect, or if its adjustment is altered but slightly, the performance of the entire receiver may be affected quite noticeably. Generally, the adjustments are not subject to change unless disturbed by untrained hands, especially if the receiver is of good design.

When any trouble is detected in a modern receiver, it remains first to check all delicate parts such as tubes, condensers, transformers, etc. A survey over a period of years has proven the following parts as being responsible for the most common receiver troubles:

Bypass Condensers	36%
Audio Transformers	25%
Resistors	16%
Switches	15%
Output transformers and speakers	5%
Miscellaneous	3%

If only those circuits that constitute the power pack of the receiver are considered, the most common causes of trouble are:

Condensers	52%
Resistors	22%
Transformers	20%
Miscellaneous	6%

You will notice that tubes are not included in the foregoing lists as they, in themselves, constitute a most common cause of radio trouble. This being true, the first rule for systematic trouble-shooting is:

NEVER DISTURB ANY OF THE RECEIVER ADJUSTMENTS BEFORE TESTING THE TUBES AND BEING ABSOLUTELY CERTAIN THAT EACH AND EVERY ONE IS IN PERFECT OPERATING CONDITION -- NEVER TAKE THE OWNER'S WORD THAT THE TUBES ARE NEW AND IN PERFECT OPERATING CONDITION.

GENERAL DIAGNOSIS OF RECEIVER TROUBLE

Radio receivers in general, no matter how complicated they may seem, are nothing more than a combination of inductances, condensers, resistors, tubes and hook-up wire. However, each part in the receiver is electrically associated with the other components so that if any one part develops a defect, the entire radio may be affected.

When analyzing radio troubles, the difficulty is not so much to determine whether or not some particular part is defective but rather which of the many parts is responsible for the trouble.

The origin of the trouble can be determined quite easily in an old receiver where the number of parts comprising the receiver is limited, and in which case a thorough check of each part can be made with ease. However, modern receivers contain a great many parts, and the circuit arrangements are quite complex so that such a procedure would require considerable time. Therefore, when analyzing troubles in modern receivers, it is important that a definite system be followed -- one which will enable you to locate the trouble accurately and quickly.

Try to avoid "guess work" as much as possible. Instead, always aim to analyze the symptoms and to employ your powers of deduction

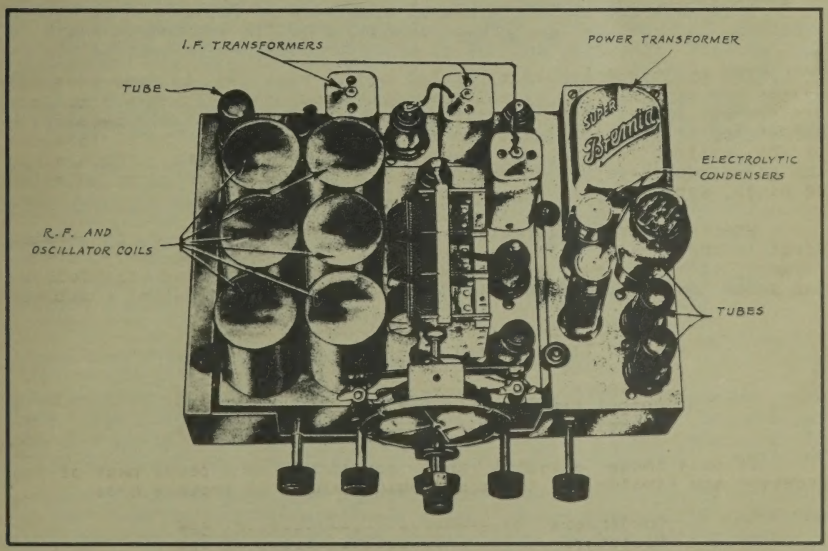


FIG. 2
TYPICAL SUPERHETERODYNE CHASSIS

according to the knowledge which you have acquired from the lessons. Never alter adjustments or loosen any connection "to see what happens" -- no adjustment can be altered nor can the connections of any wire become changed unless someone has deliberately done so.

Always bear in mind that your reputation is at stake, and that the latter procedure would be equivalent to the mistake made by any physician, who when called upon to diagnose a case, would immediately proceed to give the patient a physic, cut out his tonsils or remove his appendix, "to see what happens." The successful doctor never arrives at a conclusion nor issues a prescription without first analyzing the symptoms carefully and obtaining from the patient all information possible as to what may have brought about the affliction. In other words, while he inquires from the patient himself, or from those close to him, as to what the apparent symptoms may be, how long they have been noticed,etc., he proceeds to note the patient's temperature, examine his tongue and eyes, feel his pulse, observe the color of his skin and listen to the action of his heart and lungs with a stethescope.

In certain cases, the physician finds it necessary to make blood tests or other tests which necessitate the use of precise instruments, including "X-ray" machines and other apparatus. As a matter of fact, the efficiency of a doctor is often denoted by the type of diagnosis he performs on his patients before issuing a prescription. The same applies to the radio service technician who uses his testing instruments skilfully and diagnoses the trouble intelligently.

ROUTINE FOR DIAGNOSING RADIO TROUBLES: It is to be noted that the routine for diagnosing receiver troubles,as covered in this manual, is restricted to the general trouble-shooting methods which are to be followed when a minimum of testing equipment is available, as would be the case of a beginner in radio service work.

Instruction material furnished elsewhere in the course furnishes detailed information on how to conduct specific instrument tests on the various circuits, and how to apply precision-type testing equipment most effectively.

Under the conditions described, the diagnosis of radio defects can be greatly simplified by following the procedure outlined below:

(1) Obtain as much information as possible from the owner of the receiver.
(2) Inspect the receiver carefully and test all voltages of different circuits.
(3) Analyze carefully the results obtained from all your tests and try to locate the trouble by deduction.
(4) Test each part separately in that section of the receiver in which the trouble originates, and make the necessary repairs and adjustments.

HOW TO OBTAIN PRELIMINARY INFORMATION

When questioning your customer, be very diplomatic in obtaining the desired information,otherwise the customer may retort angrily that if you are really a radio man you should know what is wrong with the receiver.

It is quite true that the thorough training which you are now acquiring will enable you to locate any radio trouble without the assistance of the information obtained from the set-owner; however, possessing a certain amount of information regarding the problem beforehand will enable you to locate the defect more quickly.

The necessary questions may be asked casually and at convenient intervals while you remove any article that may be resting on the radio cabinet, or while you are removing the chassis from its cabinet in order to conduct preliminary tests. At the same time, you should make a note of the receiver make and model,tube layout, types of tubes,etc.

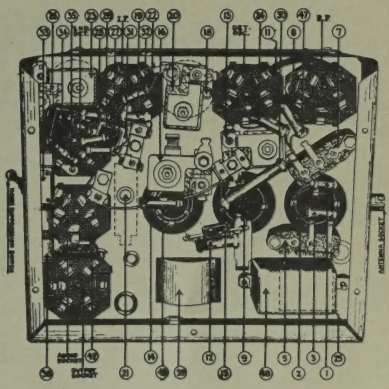
Question the set-owner in the following order:

(1) HAVE YOU HAD THE TUBES CHANGED RECENTLY?

Old tubes often cause loss of sensitivity, noisy reception and distortion. Therefore, if the set-owner admits that the tubes have not been changed for a long time, you should check them carefully and replace all defective tubes with new ones.

Normally, a radio tube will furnish approximately 2000 hours of efficient service. However, in actual practice you will find that some tubes are serviceable much longer than 2000 hours, while others may develop defects a few weeks after being installed in the receiver. Even though a weak radio tube may continue to operate a little longer, it is nevertheless advisable to always replace such tubes with new ones when servicing a set. The reason for this is that weak tubes may cause trouble a short time after you have worked on the receiver,and the owner may then hold you responsible. Your reputation will suffer under these conditions and may prevent you from conducting further business with this customer or with his acquaintances.

If the nature of the repair is such that the cost of servicing is rather high,making it impossible for you to exchange weak tubes for the price you have established for your services, then it is of course best to continue using the weak tubes. However, you should, in such a case, inform the set-owner accordingly. By explaining the situation sincerely and convincingly, he will more than likely realize the necessity of new tubes and will be willing to pay the additional amount.



RESISTORS:	NOS. 1-3-8-11-12-19-22-24-28-29-30-31-35-38-47-49
BYPASS CONDENSERS:	5-7-21-25-48
MICA CONDENSERS:	15-27-34-42
TRIMMER CONDENSERS:	13-16-20-23
R-F TRANSFORMERS:	2-9-14
I-F TRANSFORMERS:	18-26
A-F TRANSFORMER:	39
SWITCH:	33

FIG. 3
ARRANGEMENT OF PARTS BELOW THE CHASSIS

(2) HOW DID THE TROUBLE PRESENT ITSELF FROM THE BEGINNING?

Any information that the set-owner can give you in this respect is generally very helpful. For example,if he states that the receiver stopped operating after emitting a loud noise through the speaker, accompanied by a "winking" of the electric lights in the house, it is most probable that the trouble exists in the power transformer, filter

condensers, or in one of the bypass condensers. Such a defect generally causes the receiver's fuse (if it is so equipped) to burn out due to excessive current flow. This in turn affects the houselighting circuit.

Another customer may inform you that the receiver had been noisy for some time, especially when operating the volume control. From this information you will deduce that the volume control is defective.

Perhaps, the set-owner may tell you that his radio stopped operating immediately after wiping the dust off it. In this case, the defect can most likely be traced to a loose external connection. It is also possible that the owner removed some of the tubes from their sockets to do a more thorough job of cleaning and that he did not replace them in their sockets correctly, or else neglected to replace a control grid cap properly.

On the other hand, the set-owner may inform you that after noticing his receiver's failure to operate at maximum volume, he proceeded to tighten all bolts and screws that he could find loose in the set. Following such a procedure, the owner, unaware of what he was doing, may have altered some of the adjustments in the receiver's tuning circuits and thereby produced serious misalignment.

From the foregoing explanations you will more fully appreciate that the information obtained from the set-owner will in some instances help solve the problem more quickly, while in other cases it may be of no help at all. Therefore, you must not take any information obtained from a person too seriously, as some set-owners imagine symptoms, that if given too much importance, may be misleading.

(3) HAS YOUR RECEIVER BEEN WORKED ON RECENTLY?

This information may be of vital importance to you, for if the set has been worked on by an unskilled technician, the defect may be the result of faulty servicing. In cases such as this, it is advisable to check the receiver circuit carefully against the factory diagram, noting if any of the parts have been damaged, connections changed, or the circuit-design altered in any way.

The general excuse offered by the less skilled technician to hide his ignorance and appear important is to knock the manufacturer, stating that an error was made in the circuit design, that certain parts are superfluous, and other unfounded remarks of such nature. Naturally, these assertions are untrue, and if that person is permitted to "correct" the receiver circuit, he may ruin the set completely.

The correct alignment of tuned circuits must never be trusted to an inexperienced man, as that person may alter the adjustments in such a way as to make the set inoperative entirely. Lack of selectivity, howling and distortion, are frequently caused by misalignment of the tuned circuits. Under such conditions, the best procedure is to align all the tuned circuits in the receiver instead of merely trying to rectify a discrepancy which may exist in any one circuit.

(4) WHAT ARE THE SYMPTOMS OF TROUBLE, AND WHEN ARE THEY MOST APPARENT?

The main object of this question is to get an idea as to whether the set-owner is expecting too much from his radio, or if conditions exist at certain hours of the day or night that tend to alter the normal operation of the set. As an example, let us consider a case where the set-owner complains that his radio does not tune-in a certain program satisfactorily. Before going further, you must first determine

if the program desired is being transmitted from a distant station or at such a frequency that it will be practically impossible to receive it at a given hour.

A great many owners may complain that their set is subject to excessive hum which is apparent only at certain hours of the day or night. If the receiver operates efficiently during most hours, but produces the noise mentioned only at one particular hour of the day or night, then it is obvious that the disturbance does not originate in the set but is being induced into the antenna circuit. Most likely, such a noise is being produced by some electrical appliance in the neighborhood, which can be eliminated only by locating the source of the disturbance and eliminating it at that point.

In certain cases it may be possible to eliminate interference by using a modern antenna installation, but not always. For instance, if the source of interference is such that its field does not reach the horizontal antenna wire, the trouble may be eliminated completely by the use of one or another of the noise-suppressor types of antenna systems. However, if the field of the interference source does reach or envelop the horizontal wire of the antenna installation, then no matter what make or type of antenna you use, you will never be able to overcome the trouble.

To illustrate this point, let us suppose that we have an installation such as shown in Fig. 4, where a doublet antenna is being used. Let us further suppose that two electric motors are located in the neighborhood so that their fields of interference extend outward as shown in the illustration. Under such conditions, the particular antenna installation shown will eliminate the interference produced by motor #2, but not that of motor #1.

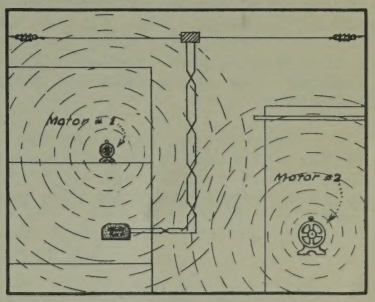


FIG. 4
THE INTERFERENCE PROBLEM

In cases like these, the only remedy is to call on the owner of motor #1 and suggest that he install, in the motor circuits, filters of the type shown you in one of your lessons dealing with interference elimination.

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PRELIMINARY INSPECTION OF THE RECEIVER

The efficient radio serviceman bases the diagnosis of all his service jobs on the information obtained, the presence of certain characteristic symptoms, the indications of his testing instruments and on other special tests. Such a serviceman does not proceed to disassemble a set the minute he arrives at the customer's home, but tries first to obtain all the information previously mentioned, and pauses to meditate and form concrete deductions. The more complete the technical knowledge possessed by the technician, the quicker will he arrive at a correct analysis of the trouble.

To better illustrate the correct procedure for analyzing the condition of an inoperative receiver, let us consider an a-c receiver which is completely "dead." The first step in this case is to observe whether or not the tube filaments are operative. (Some tubes show hardly any light, whereas metal tubes do not show any light at all.

In the latter case one can only determine if the filaments are functioning by noting the heat emitted from the tube's metal shell.)

If the tube filaments do not light, the defect may be found in the a-c input circuit, line cord or "on-off" switch. The procedure for locating this trouble is obvious.

If the tube filaments light up O.K., then the next step is to check the plate voltage, by testing with a d-c voltmeter between the plate and cathode terminals of the various tube sockets. (If the tubes are not of the cathode type, the test should be made between the plate and one of the filament terminals on the tube socket.) If no d-c voltmeter is available, the test can be made by forming a momentary short-circuit between the two terminals mentioned, using a piece of wire. The latter test should result in a bright, snappy spark as contact with the circuit is momentarily completed and interrupted.

In the event that none of the aforementioned voltages are present, the trouble is then in the power unit. Therefore, that portion of the receiver must be checked thoroughly and the defect corrected. If you find plate voltages at all but one or two of the tube sockets, you will immediately arrive at the conclusion that the plate circuit for that particular tube or tubes is open. (However, bear in mind that a high-resistance connection may have developed in the plate circuit, causing the spark obtained from the above-mentioned test to be hardly noticeable.)

Now, let us consider the case of an all-wave receiver which operates efficiently on all wave-bands but one. Through simple reasoning, we can readily see that the trouble may be found in the tuned circuit corresponding to that particular wave-band which is found to be dead.

HOW TO CHECK THE POWER SUPPLY

When the information acquired from the set-owner suggests a short circuit, and if you observe evidences of burned insulation upon turning the chassis over, you must be careful not to connect the receiver to the power line, as this may result in a fuse blow-out, which would put you in a very ridiculous position in the eyes of your customer.

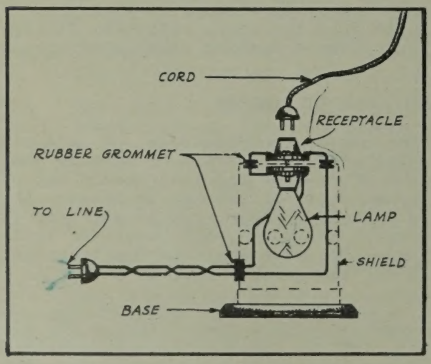

FIG. 5
A PRACTICAL TEST-LAMP

Under such conditions, the lighting circuit should be protected by inserting a 75 or 100-watt lamp in series with it and the receiver. Fig. 5 shows a practical test-lamp which may be used under the conditions mentioned, and preferably in every case when a radio set is to be connected to the power line for the first time after a repair job.

DETAILS FOR CONSTRUCTING A TEST LAMP: The particular test-lamp shown in Fig. 5 consists of a metal can, inside of which is mounted a lamp socket and a lamp of the size mentioned. (The voltage rating of the lamp should correspond with the line voltage with which it is

to be used.) On the outside of the can is mounted a receptacle, and connected in such manner that both this receptacle and the lamp socket are connected in series with the receiver line-cord and plug as also shown in Fig. 5.

You will further observe that each hole in the metal shield, through which the wires pass, is fitted with a rubber grommet (bushing) to eliminate all possibility of shorts. The dotted circles indicate holes drilled in the metal shield, and through which one can observe the intensity or brilliance of the lamp enclosed therein.

As you will see in Fig. 5, the base of the test-lamp is made of wood. A felt cover is placed on its exposed lower surface to prevent scratching the receiver cabinet in the event that the test-lamp is placed on top of the receiver while conducting a test.

APPLICATION OF TEST-LAMP: To use the test-lamp, simply insert the plug at the end of the receiver's line-cord in the test-lamp's receptacle, and connect the line-cord of the test-lamp proper to the receptacle that connects to the houselighting circuit. In this way, the lamp will be connected in series with the receiver and power-line circuit.

If, upon completing the circuit connections in the manner described, you note that the lamp lights at maximum brilliance, it indicates that a very serious short exists either in the power transformer or filter condensers. Normally, the lamp will show a very weak light upon first closing the receiver switch, when the tester is connected in the circuit, but its brilliance will increase as the tubes "heat up" and the receiver begins operating; however, the lamp will never attain maximum brilliance, as in the case of a short-circuit in the power pack. (It is to be noted that the greater the number of tubes used in the receiver, the more brilliant will the test-lamp burn when all tubes are at operating temperature so as to place the power transformer under load.)

This same test can be applied in the following manner to determine the condition of the power transformer:

After the connections have been made and the receiver tubes attain normal operating temperature, remove one tube at a time, leaving the rectifier for the last. Under normal conditions, the lamp's brilliance will diminish as each tube is removed, and will finally die out completely upon removing the rectifier tube.

Whenever the lamp lights brilliantly with only the rectifier tube in the circuit, but "goes out" completely when the rectifier tube is removed from the chassis, it indicates that there is a "short" in the filter circuit or in the rectifier tube.

If, after removing all of the tubes, the lamp still lights at maximum brilliance, then the defect is in the power transformer (most probably shorted internally), or a bypass condenser connected across the primary.

Care should be exercised when removing the tubes from the chassis, to see if the sockets are marked in accordance with the tube numbers; otherwise, it is necessary to mark the chassis near each tube with the number of the tube removed therefrom. By following this procedure you will always be sure to replace each tube in the proper socket.

SPECIAL SUGGESTIONS FOR D-C AND AC-DC RECEIVERS: If the set being checked is of the d-c or ac-dc (universal) type, and the test-lamp lights at practically its full normal brilliance when connected between

the receiver and the line, then there is a short-circuit in either the line-input circuit or in the "B" circuit. In such a case, proceed by removing any of the tubes but the rectifier. If the lamp continues to burn but "goes off" immediately upon removing the rectifier from its socket,then the trouble is located in the rectifier system. If, after removing the rectifier tube the lamp continues to burn, the defect may be in the "on-off" switch or in a bypass condenser that is connected across the line or line-cord.

The test-lamp in question can also be used to locate the burned-out filament in an ac-dc or straight d-c set if the set is inoperative due to an open circuit. This can be explained as follows:

As you already know, the filaments in a d-c or combination ac-dc receiver are all connected in series; therefore, if any one filament burns out, all of them will be extinguished simultaneously. If the tubes are of the metal type so that their filaments are not visible, connect the test-lamp in series with the receiver's line-plug and the lighting circuit as previously described. An open filament in any one of the tubes will not permit the test-lamp to burn.

To locate the open filament,short-circuit the filament terminals at one of the tube sockets temporarily. If the test-lamp still fails to burn, it indicates that one of the other tube filaments is burned out. Therefore, proceed by short-circuiting the filament terminals at another socket and observe the behavior of the test-lamp. Should the test-lamp burn as you short-circuit the filament terminals at one of the tube sockets, then you know that the filament of that particular tube is burned out.

REMOVING THE CHASSIS FROM THE CABINET

The results obtained from the test previously mentioned will show whether the trouble is simply a burned-out tube, some other defect equally easy to repair, or trouble of a more serious nature. It is recommended to proceed immediately by testing all of the tubes, using a good tube checker.

In the event that you do not possess a good tube checker, remove the tubes from the set (marking their respective sockets conveniently for correct replacement), and take them to the nearest radio supply store for testing. Any radio supply store will test tubes free of charge, provided that you purchase the replacement tubes from them. However, under such conditions, it is always best to inform the set-owner that you must take the receiver to your shop for further checking, but that you will inform him as to the repairs required and give him an estimate as to the approximate cost of repairs, etc., before actually starting to make the necessary corrections and replacements.

If you have equipment for checking the tubes in the owner's home and have determined that the tubes are in perfect operating condition, but that the receiver fails to operate, then the receiver must be taken to the shop where you can make a more thorough check of all circuit components. IN FACT, IT IS RECOMMENDED THAT THE CHASSIS BE REMOVED FROM THE CABINET AND TAKEN TO THE SHOP WHENEVER THE REPAIR JOB REQUIRES ANY AMOUNT OF TIME, AS IT IS NOT GOOD PRACTICE TO MAKE MAJOR REPAIRS IN THE CUSTOMER'S HOME.

If the receiver to be repaired is of the midget or table-model type, then the best practice is to take it to your shop complete with cabinet. However, if the set is of the console type, it is usually necessary to remove the chassis from the cabinet and to take only the receiver proper to the shop for repairs. In the latter case, be sure to take the speaker along with the chassis.

The best method for removing the chassis from the cabinet is generally obvious upon making a brief inspection of the receiver. Be careful to keep all bolts, nuts, washers, etc., together (preferably in an envelope). Make a note of the receiver make and model on the envelope so that you will always know exactly to which receiver they belong in case that you are working on several receivers at one time.

Knobs should be kept on their respective shafts. Some knobs are held in place with the aid of set screws, while others are held in position by a press-fit. In the latter case, it is only necessary to pull firmly on the knob to remove it.

Be especially careful not to damage the speaker cone when removing the speaker from the cabinet. When using it on your work bench, always place it face down.

HOW TO IDENTIFY THE VARIOUS STAGES OF THE RECEIVER

When checking a receiver, it is recommended that all components such as i-f transformers, r-f transformers, a-f transformers, etc., be identified first, since this simplifies the checking procedure considerably. The majority of modern receiver circuits are of the superheterodyne type, in which case the set is divided into sections as shown in Fig. 6. In the t-r-f receivers the i-f and oscillator circuits do not exist.

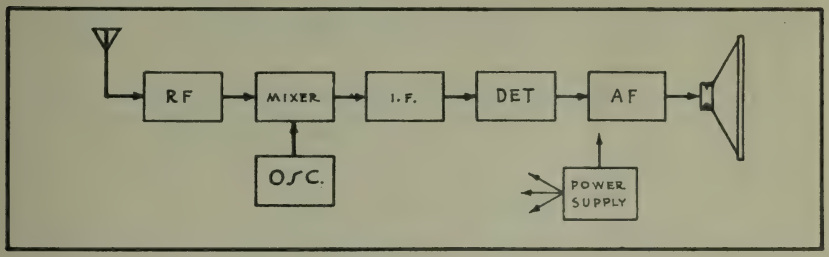

FIG. 6
SECTIONS OF A SUPERHETERODYNE RECEIVER

HOW TO TRACE THE CIRCUIT AND PREPARE A SKELETON DIAGRAM: To one possessing experience, the correct identification of radio parts is a simple matter. However, the beginner can also identify the major sections readily by tracing each of the principle circuits individually. The latter comprise the antenna circuit, and the grid and plate circuits of each tube.

To assist you in this matter you can sketch on a piece of paper the approximate location of the tubes, coil shields, and transformers as illustrated in Fig. 7. The next step is to examine the main wiring leads, carefully following the path along which the signal travels through the complete circuit.

Starting from the antenna terminal, trace through the antenna coupling transformer and also the band-selector switch (in case the receiver is of the all-wave type), to the control-grid of the tube to which it is connected. Then continue from the plate of this tube (No. 1) to the r-f coil (tracing through the band-selector switch when necessary), and from that coil or group of coils to the control-grid of the next tube (No. 2).

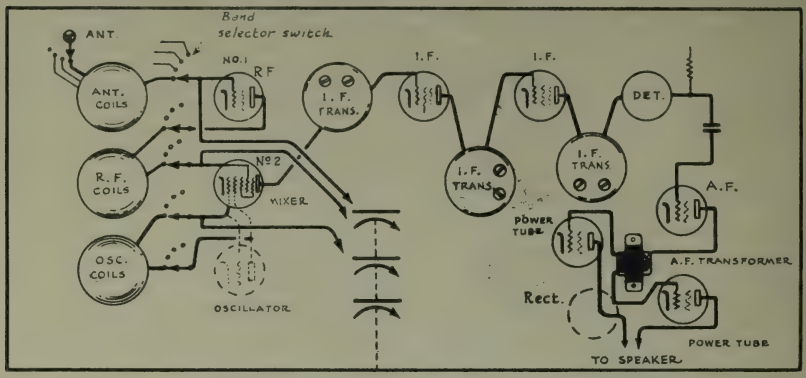

FIG. 7
ANALYZING THE CIRCUIT ARRANGEMENT

Continue by tracing the wiring from the plate of the second tube to the coil that is connected to the control grid of the next tube. Continue in this manner by tracing the hook-up between the plates and control grids of all tubes in the receiver.

The tuning coils or r-f transformers are identified easily because of their connection to the ganged tuning condenser. The i-f transformers are coils of fine wire, generally honeycomb wound, with compensators connected across each winding. By noting to which type of transformer it is connected, the function of a given tube can be ascertained readily.

In the case of a superheterodyne circuit, an oscillator coil or group of oscillator coils, will be found connected to the elements of a converter tube or individual oscillator tube. The "mixer," audio and detector tubes are easily identified by noting the connections of the main leads in these circuits and also by the code numbers of the tubes. The same can be said of the rectifier tube,in case one is used.

To simplify matters in this circuit check-up, we have prepared Table I, showing the common tube connections in a receiver. However, you must bear in mind that there are special circuits to which this table cannot be applied.

TABLE I

COMMON TUBE CONNECTIONS

SECTION	CONTROL GRID TO:	PLATE TO:
R-F AMPLIFIER	ANT.COIL OR BAND-SEL. SWITCH	R-F COIL OR BAND-SEL. SWITCH
MIXER	R-F COIL OR BAND-SEL. SWITCH	I-F TRANSFORMER
OSCILLATOR	OSC.COIL OR BAND-SEL. SWITCH	OSC.COIL,BAND-SEL.SW.,OR COND.
I-F AMPLIFIER	I-F TRANSFORMER	I-F TRANSFORMER
GRID LEAK OR POW.DET.	I-F OR R-F TRANSFORMER	CONDENSER OR A-F TRANSFORMER
DIODE DETECTOR	NONE	I-F TRANSFORMER
A-F AMPLIFIER	CONDENSER OR A-F TRANSFORMER	CONDENSER OR A-F TRANSFORMER
POWER AMPLIFIER	CONDENSER OR A-F TRANSFORMER	OUTPUT TRANSFORMER

We have not included the rectifier tube in Table I because its code number and special connections make it a simple unit to identify.

Systematic Trouble-Shooting

In many cases, the preliminary tests, or the nature of the signals heard, will immediately disclose the cause of the trouble. However, in such cases where the receiver is completely dead, it is necessary to conduct the systematic tests which have been recommended previously in this manual. Although there are some exceptions, the routine tests should be conducted in the following order:

(1) Test the power-input circuit and power supply (whichever type is being used).
(2) Test all tubes.
(3) Check all tube voltages at base of sockets.
(4) Check speaker and audio stages.
(5) Check operation of detector.
(6) Check stages preceding the detector.
(7) Check all special circuits.

These tests are described more fully in the following paragraphs.

TEST FOR POWER INPUT-CIRCUIT AND POWER SUPPLY

We have already described the method for conducting the preliminary tests on a-c receivers. In the case of a battery set, the preliminary test should include checking the condition of the batteries before testing the receiver.

Batteries are tested by checking their voltages when the receiver is in operation; that is, when the set is drawing a normal load current. Under these conditions, the correct values are as follows:

"A" battery -- If dry cells are used, the voltage should not be less than 1.4 volts. Air-cells should read 1.15 volts, and air-batteries (2 cells) should read 2.3 volts. Each cell of a storage battery should read 2 volts.

"B" battery -- 22½ volt "B" batteries should not read less than 18 volts; 45-volt batteries should read not less than 36 volts.

TUBE TESTING

We have already mentioned the importance of determining the exact condition of each tube used in a receiver. If a good tube tester is available, the tubes should be checked in the customer's home, so that he can see for himself which tubes should be replaced. This method will prove more satisfactory when he receives his repair bill and he will also better appreciate your technical knowledge.

However, in starting a radio service business, it is not essential to buy a tube tester. You can tell the owner that it is necessary to take the set to the shop for a complete check-up, as in the shop you have the necessary instruments for conducting a complete analysis. At the same time, you can mention that you will also check his tubes to determine if any are bad, and that you will get in touch with him to quote the cost of the complete job before purchasing them. You can then have the tubes checked at your local radio parts dealer.

NEVER REPAIR A SET WITHOUT FIRST TELLING THE OWNER THE APPROXIMATE COST, AND OBTAINING HIS APPROVAL.

Many customers are very suspicious, and for this reason it is best to show them which tubes were replaced. Usually, this is all that is necessary, but if the owner asks for the old tubes, it is best to have them ready to relieve his suspicions.

Many radio dealers and servicemen have adopted the practice of attaching a sticker to each tube that they test. The date of test, condition of the tube, and name of the dealer all appear on this sticker. If the tube is not as good as it should be, the dealer generally tries to sell the customer a new tube but returns the old one to him so that he can use it in an emergency at some later time.

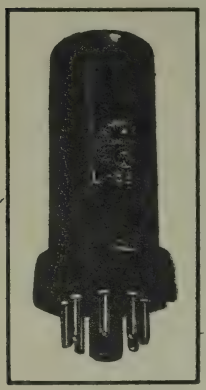

FIG. 8
BALLAST TUBES LOOK LIKE REGULAR TUBES

When working on combination ac-dc receivers that are equipped with a ballast tube, you must be especially careful not to mistake the ballast tube for one of the regular tubes in the set. Ballast tubes are not checked on a tube-checker -- instead, their resistance element should be checked for continuity and value with a low-reading ohmmeter. Since ballast tubes are available in different resistance values, you must be sure that the replacement unit has the same value as the original, especially if it is of different manufacture. The code number appearing on the ballast tube identifies the type and resistance value of the unit. In Fig. 8 is shown one of these ballast tubes, the appearance of which is similar to that of an ordinary metal radio tube.

TEST FOR VOLTAGE VALUES

Voltage tests are usually made with a multi-scale voltmeter, applying the test leads to the socket prongs underneath the chassis, without removing the tubes. When following this procedure, the electrical characteristics of the circuits involved will not be altered and will therefore not introduce an error in the meter readings. The old method of removing the tube from the receiver, and plugging it in the analyzer socket, is not recommended when checking modern receivers of high-amplifying ability, as the capacity and inductance introduced by the meter connections may cause oscillations and thereby affect the meter reading.

In Fig. 9 is shown how by applying the negative test-lead to the cathode and touching the positive lead alternately to the plate, screen grid, suppressor-grid terminals, etc., these various voltages may be measured. It is advisable to jot down the values obtained in the form of a table for later use in checking for abnormalities.

The correct voltages at the sockets vary according to the design of the receiver and type of tube. Although they can be checked against corresponding values specified for the same tube-type in characteristic tables, it is considered better practice to check these values with those specified by the manufacturer of that particular set. Careful consideration should be given to the function of each tube in that particular receiver and also to the circuit design in general, as you may obtain readings that at first may not check with general specifications but which may be entirely satisfactory for the set in question.

For example, if the tube happens to function as a detector, having a resistor of high value installed in its plate circuit, the voltmeter may indicate an exceedingly low plate voltage reading, when in

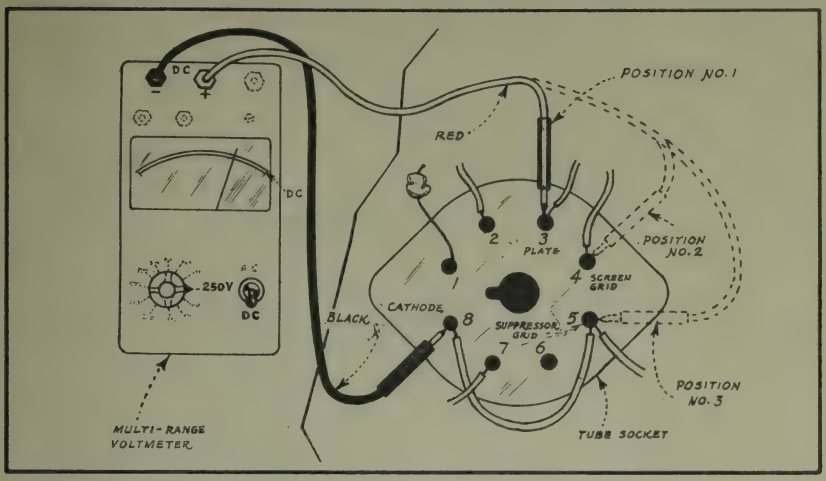

FIG. 9
CHECKING VOLTAGES AT A TUBE SOCKET

reality it is much greater than is apparent, depending upon the sensitivity of the voltmeter that is being used for the tests. For instance, if the plate voltage is read with an instrument having an internal resistance of only a few ohms-per-volt, the reading will be much lower than would the value shown by a voltmeter having an internal resistance of 1000 or more ohms-per-volt.

Another point worthy of mention is that the voltages in a receiver do not necessarily have to be exactly the same as those shown by the manufacturer's instructions or those shown in vacuum-tube characteristic tables. It is permissible to allow a 20% variation in receivers that are operated from a lighting circuit, whether a-c or d-c. In other words, if the manufacturer states that the plate voltage should be 250 volts, it is permissible to accept a reading of 200 volts, provided that this reading is obtained in all plate circuits that are recommended for 250-volt operation.

If the voltage is low in only one of the circuits, it indicates that an abnormal condition exists. It is then necessary to check all the parts of that circuit, particularly the carbon resistors. It is not always necessary to test the voltages at all the tubes, as the advisability for this depends primarily upon the performance of the receiver in general, and the deductions made from the tests that have already been conducted up to this time.

TESTING THE SPEAKER AND AUDIO STAGES

These tests are necessary in certain cases, as when the receiver is completely dead, when there is distortion, or when there is very little volume. Sometimes, checking the voltages will indicate the cause of the fault, especially in the case of an open circuit, or where the value of a resistor has changed with use. However, there are cases where everything appears to be in good condition but where trouble still exists.

Frequently, the condition of the audio amplifier and speaker can be determined by merely touching the control-grid connection of the first audio tube with a finger; a characteristic hum or noise will be heard in the speaker if the audio amplifier and speaker are in good condition. (This test should be made with the volume control set at its "full-on" position.)

If there is no response from the speaker during this preliminary test, it is then necessary to conduct a further test of the first audio stage, then the second, third, etc., until you arrive at the output stage. The latter test is made with a pair of headphones connected in series with two condensers in the manner illustrated in Fig. 10. The capacity rating of the condensers may be any value between .001 and .05 microfarad.

The object of using two bypass condensers in series with the headphones is to prevent the passage of d-c current. It is important to use the two of them as in some receivers (d-c or ac-dc combination sets in particular), the chassis is connected to the power line and there is then a possibility for receiving an electric shock if the headphones should be connected directly to the circuit without inclusion of the condensers.

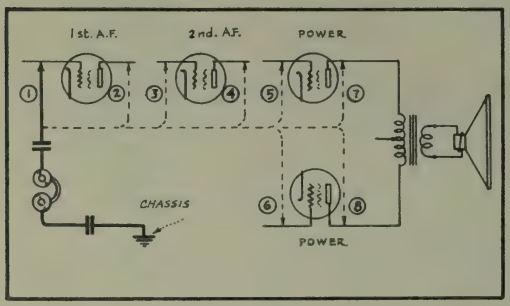

FIG. 10
SEQUENCE FOR A-F STAGE TEST

Upon the examination of Fig. 10, you will note that we first connect the headphones between the chassis and the control grid of the first a-f tube. If no signals are heard, it is an indication that trouble exists at some point preceding this stage, and in which case it will be necessary to check back through the detector and i-f or r-f stages.

If signals are heard when the headphones are connected in position #1 of Fig. 10, but are not reproduced by the speaker, proceed to connect the headphone-leads to the plate of the first audio tube and to the chassis, as indicated by position #2 in Fig. 10. Continue in this way, gradually approaching the speaker as indicated by positions #2, #3, and #4, etc., until you arrive at the position where signals are not heard in the headphones.

Let us suppose, for example, that signals are heard when the headphones are connected in position #4 in Fig. 10 but not in position #5. Such being the case, we can be sure that the trouble exists in the coupling between the second a-f and power output stages. We would then test this coupling, which may be in the form of a resistance-condenser combination or an a-f transformer.

If signals are heard in the headphones after we arrive at the plate circuit of the power tube or tubes, and the speaker is still dead, then it is an indication that trouble exists in the secondary winding of the output transformer, the speaker voice coil, or their connections.

A SIMPLE HEADPHONE ADAPTER: To eliminate the necessity of making connections to the bypass condenser, headphones, and test leads while conducting the tests just described, we suggest the use of the simple adapter illustrated in Fig. 11.

As can be seen by examining the illustration, the adapter comprises a bakelite cylinder which encloses the condensers; the test leads and headphone leads are plugged into jacks mounted on the bakelite or other insulative covers that are installed at the ends of the cylinder.

In constructing such an adapter, proceed by first cutting the covers to a diameter that will allow them to fit snugly inside the cylinder; next, mount the jack on the covers and solder the condenser leads to them. The leads should be long enough to allow the covers to be mounted flush with the ends of the cylinder.

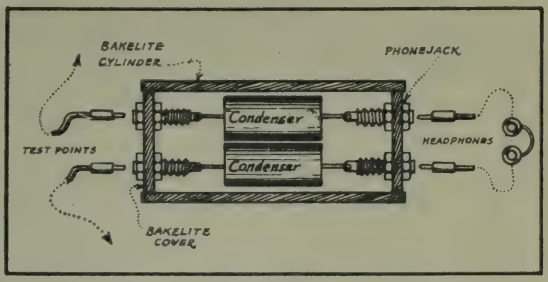

FIG. 11
HEADPHONE ADAPTER

The assembled unit is then inserted in the cylinder and the covers are fastened in place with liquid cement or acetone. The jacks on one end are for the test-lead tips while those on the opposite end are for the headphone lead-tips. As has already been stated, the bypass condenser may have any capacity between .001 and .05 mf, and should have a normal working voltage of not less than 400 volts.

TESTING THE DETECTOR AND R-F STAGES

Trouble in the detector, r-f, i-f, or mixer stages is usually confined to the tubes or bypass condensers.

In the case of a shorted bypass condenser, the voltage on the plate, screen grid or some other tube element will be affected; if a control grid circuit or grid coil should be open, no voltage will appear at the control grid; if a plate winding is open, no voltage will be available at the plate, etc. In this manner, the defective part or parts can be located quite easily.

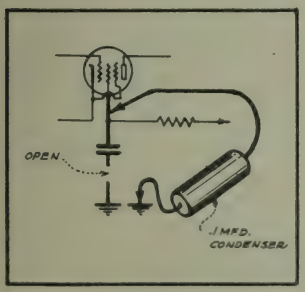

FIG. 12
SIMPLE CONDENSER TEST

However, there are cases where the damaged parts will not affect the d-c voltage. Special care and good judgment must then be exercised to locate the defect. An open bypass condenser serves as a good example of this, as such a condition does not affect the d-c voltages but yet impairs the performance of the receiver.

Open condensers are located readily by connecting another condenser in parallel, as shown in Fig. 12. To facilitate

matters, the condenser used for such testing purposes should be supplied with long leads, one of which is connected to the chassis as shown. The other lead is used to establish contact with the ungrounded sides of all the bypass condensers in the receiver, as they are tested in successive order.

If the condenser under test is in good condition, no apparent change in receiver performance will be noted upon connecting the test condenser in parallel with it -- but if an improvement occurs or the trouble disappears entirely -- it indicates conclusively that the condenser under test is open.

The .1 mf capacity specified in Fig. 12 is suitable for testing the majority of receiver circuits in this way. However, when checking special circuits where condensers of lower capacities are used, a test condenser of approximately corresponding capacity should be employed. Whenever this test discloses a defective condenser, the faulty condenser should be replaced with another of the same capacity-rating.

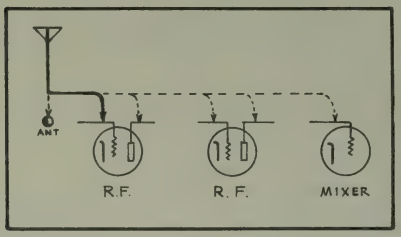

Fig. 13
Sequence for R-F Stage Test

Trouble in the r-f and input circuit of the mixer can be found by touching the antenna lead to the control grid and plate connections of the r-f tubes, or to the control grid of the mixer tube, as shown in Fig. 13. In many cases it is only necessary to touch these terminals with a finger, the capacity of the human body being sufficient for adequate signal pick-up.

The plate circuit of the mixer tube cannot be checked in this manner, as it is tuned to a frequency other than that of any conventional broadcast station -- the same applies to the i-f stages. However, if a service oscillator (signal generator) is available, its signal can be applied to the control grid of the mixer or i-f stages for this test, using a signal-frequency for which the i-f stages of the receiver have been tuned.

HOW TO TEST THE OSCILLATOR

Operation of the oscillator in a superheterodyne receiver can be checked quite easily when the receiver is equipped with a visual tuning indicator, such as a magic eye, shadowgraph, milliammeter, etc. In this case, it is only necessary to turn "on" the set, and when the tubes have reached operating temperature touch the oscillator control-grid terminal with a finger. If this is not convenient, finger-contact can be established at any other suitable point of the control-grid circuit as, for example, the stationary plates of the tuning condenser section for that circuit. If the oscillator is in an operating condition, a noticeable change will be observed on the tuning indicator. If no change takes place at the tuning indicator during this test, you will know that the oscillator is inoperative.

If the receiver in question is not equipped with a tuning indicator, we can conduct this test in a more scientific manner. Namely, by connecting the antenna terminal of a service oscillator to the control grid of the receiver's oscillator tube through a .00025 mf condenser, as shown in Fig. 14. Note that the grid is disconnected from the receiver circuit during this test. The "ground" terminal of the oscillator should be connected to the chassis of the receiver.

Next, set the receiver dial on a position where it is known that a powerful station is normally tuned-in, and tune the service oscillator to a frequency equal to the sum of the broadcasting station and the i-f of the receiver. For example, if the receiver is tuned to a station operating on 900 kc and has its i-f peaked at 450 kc, tune the service oscillator to a frequency of 900 + 450, or 1350 kc.

If the station program is now heard satisfactorily, you will know that the receiver's oscillator is inoperative, and that all other sections of the set are in working order. If this application of the service oscillator does not make possible reception of a broadcast program, it indicates that the trouble is in some other part of the receiver.

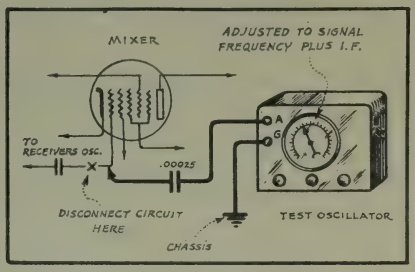

FIG. 14
CHECKING THE OSCILLATOR

Defects in special circuits such as in the a-v-c or a-f-c system, will affect the operation of the receiver in accordance with the duties they perform, in which case one may become suspicious of their condition. In case of a suspected fault in such sections of the receiver, there is no alternative but to test and adjust each part in each of the circuits involved.

Most Common Troubles

The tabulated data that follows will furnish you with a handy source of reference pertaining to receiver troubles. However, in using this information you must bear in mind that only the most common troubles are included herein. It would be almost impossible to include in such a table every possible receiver trouble.

The troubles listed apply to a-c, d-c, universal (ac-dc combination), and battery-operated receivers. For this reason, some of the troubles mentioned apply only to certain types of receivers. The apparent effect or symptom is stated first, followed by the most probable cause or causes.

NONE OF THE FILAMENTS LIGHT:

(1) Plug of receiver power cord disconnected from lighting circuit.

(2) Broken cord. No current at receptacles of lighting circuit.

(3) Blown fuse. Fuse not screwed in tightly.

(4) "On-off" switch of receiver defective.

(5) Primary winding of power transformer open.

(6) Short-circuited power transformer winding. (Indicated by a loud hum and excessive heating of the transformer.)

(7) Ballast resistor of filament circuit open.

(8) Filament of one or more tubes burned out. (In receivers with tubes in series.)

(9) "A" battery dead or disconnected.

(10) Loose or corroded "A" battery connection.

(11) Poor connection between receiver and automobile chassis. (In automobile receivers.)

RECEIVER DEAD (CORRECT VOLTAGES AT SOCKETS):

(1) Antenna disconnected. Ground disconnected.

(2) Antenna grounded.

(3) Lightning arrester shorted. (Disconnect antenna and use in its place a length of insulated wire.)

(4) R-F or i-f transformer coil shorted or open.

(5) Transformer terminal grounded.

(6) Variable condenser or compensator shorted. (Rotor plates touch stationary plates, or mica insulation damaged.)

(7) Open circuit in speaker.

(8) Defective tube. Bypass condenser shorted.

(9) Defective volume control. Control-grid connections of a tube grounded.

RECEIVER DEAD (NO PLATE VOLTAGE):

(1) Defective rectifier tube. Defective power transformer.

(2) Shorted filter condenser. Shorted bypass condenser.

(3) Open choke or speaker field coil.

(4) High-voltage end of resistor grounded. Accidentally grounded circuit connection.

(5) "B" batteries disconnected or dead.

(6) Damaged vibrator (in 6-volt receivers).

(7) Line-plug reversed (d-c receivers).

ALL INCOMING SIGNALS VERY WEAK, OR POOR DISTANCE RECEPTION:

(1) Defective tube or tubes. Antenna or ground in poor condition.

(2) Receiver located in a "shielded area."

(3) Incorrect voltages at sockets. Tuned circuits out of alignment.

(4) Very low line-voltage.

(5) Speaker in poor condition. Resistor in poor condition.

(6) Bypass condenser shorted or opened.

(7) Circuit not properly neutralized. I-F transformers not adjusted properly.

(8) Open circuit in r-f or i-f transformer.

(9) Defective volume control. Tone control condenser shorted or leaking.

(10) Corroded or loose connection. Loose contact at tube socket.

(11) Weak batteries. Open coupling condenser.

(12) "Local-distant" switch in poor condition.

FADING SIGNALS:

(1) Normal for distant stations.

(2) Loose or corroded connections. Inefficient tubes.

(3) Poor tone control or volume control. Defective speaker.

(4) Antenna rubbing on some object. Broken or poor ground connection.

(5) Tube with broken filament which lights when cold and is extinguished when heated.

(6) Partially open audio transformer.

(7) Leaky bypass condenser. Defective filter condenser.

(8) Resistor whose value varies periodically.

(9) Partially opened r-f or i-f transformer.

(10) A-V-C circuit inoperative. (Defective condenser or resistor.)

(11) Serious fluctuations of line voltage.

LACK OF SELECTIVITY ON SEVERAL FREQUENCIES:

(1) Poor tube or tubes. Antenna of excessive length. Poor ground.

(2) Receiver not aligned properly. (Various trimmers and i-f transformers require adjustment.)

(3) Defective r-f or i-f transformer. Poor volume control.

(4) Variable condenser or bypass condenser in poor condition.

(5) Receiver too close to the transmitting station. Defective resistor.

SIGNAL DISTORTION (POOR TONE):

(1) Defective tube or tubes. Too much volume. Incorrect voltages.

(2) Power tubes do not match. Defective detector.

(3) Imperfect tuning due to incorrect dial-setting or misalignment of set.

(4) Defective cathode bypass condenser. Open or short circuited tone-control condenser.

(5) Changed value of a resistor. Lack of a shield.

(6) Defective speaker (especially cone or voice coil).

(7) Receiver oscillating. Filament voltage too low.

NOISY RECEPTION:

(1) Static (cannot be avoided). Local disturbances caused by electrical appliances in the neighborhood.

(2) Loose antenna or ground connections. Defective tube, or tube loose in the socket.

(3) Loose pilot light. Loose or corroded connections. (Jar connections while set is in operation.)

(4) Dust or foreign matter between the plates of variable condenser.

(5) Loose or defective fuse. Antenna lead-in or ground wires loose.

(6) Coil partially open.

(7) Fuse or lamp in the houselighting circuit loose in socket, or damaged.

(8) Defective tone or volume control.

(9) Partially opened bypass condenser. (Difficult to locate in many cases.)

(10) Microphonic tube,or one with loose elements. Weak batteries.

(11) Defective power transformer winding.

(12) Temporary short-circuit of a bypass condenser.

(13) Control grid circuit open (motorboat noises).

EXCESSIVE HUM (IN A-C RECEIVERS):

(1) Power tubes do not match. Rectifier tube weak or defective.

(2) Poor detector. Incorrect tube voltages.

(3) Open or leaky filter condenser. (Very common)

(4) Antenna very close, and parallel to, high-voltage lines. Poor ground connection. Power transformer in bad condition. Loose laminations in power transformer.

(5) Defective bypass condenser. Resistor that has changed its value.

(6) Lack of shields.

(7) Filter choke or field coil shorted. Audio transformer placed too close to power transformer.

(8) Hum-control out of adjustment. (Old models)

(9) Cathode and filament shorted in a tube.

OSCILLATIONS (SQUEALS OR HOWLS):

(1) No ground connection, or ground-wire too long.

(2) Defective bypass condenser. Loose connections.

(3) Shields loose or do not make a good electrical connection.

(4) Poor tube or tubes. Speaker frame not connected to ground.

(5) Incorrect adjustment of r-f or i-f transformers.

(6) Imperfect neutralizing (neutrodyne sets).

(7) Very high plate voltage. Antenna too long or too short.

(8) Screen grid voltage too high. Control-grid circuit open. Poor tube contacts.

(9) Too much volume. Microphonic tube. Speaker too close to chassis.

(10) Insufficient cathode bias.

As mentioned earlier in this Manual, the instruction as presented herein is of an elementary nature, showing you how to analyze the most common types of receiver problems with a minimum of testing equipment. However, you will receive additional service instruction later on that explains in detail how to analyze receiver troubles with the aid of precision-type testing equipment.

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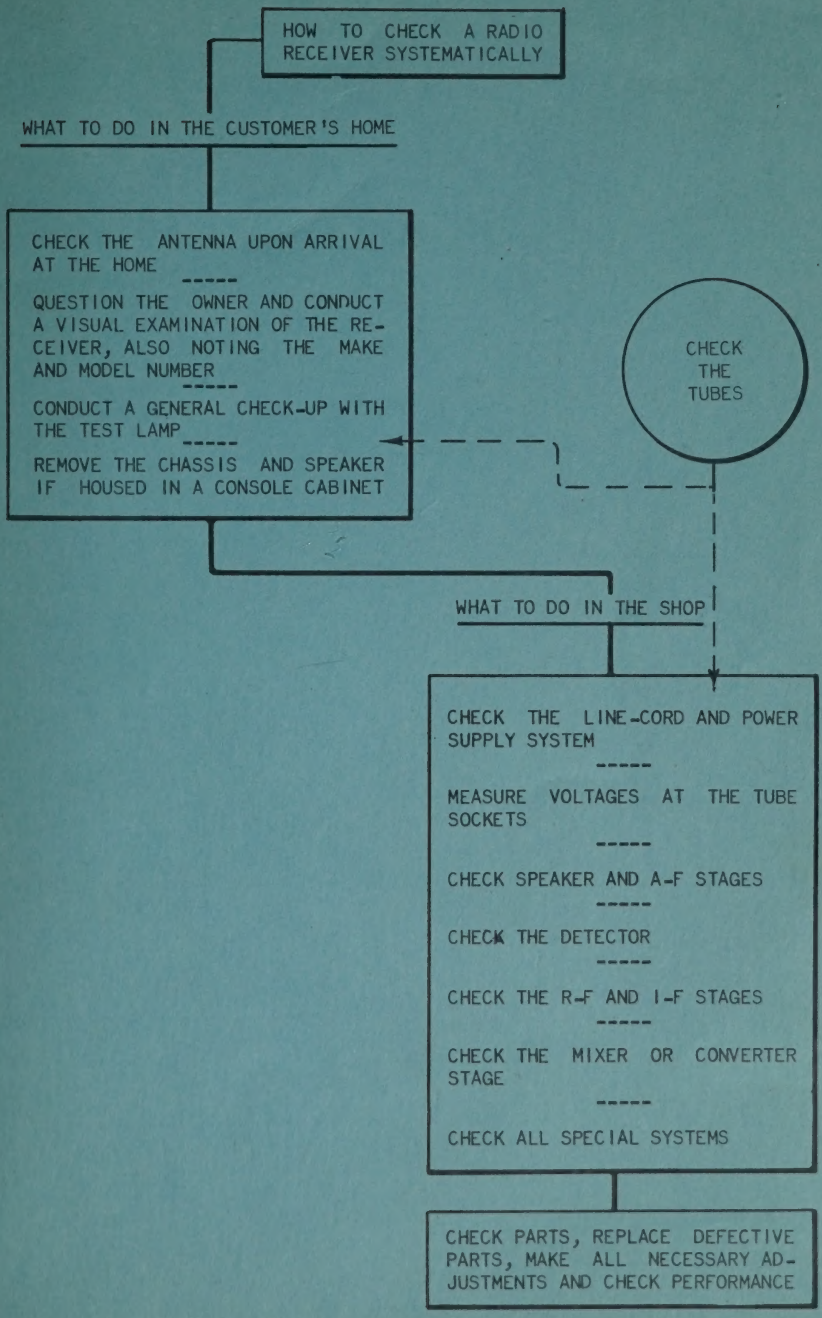
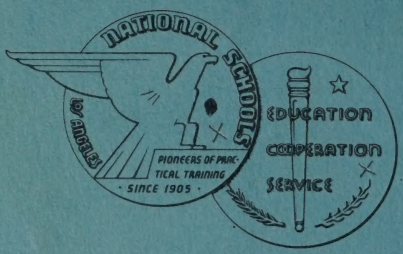

HOW TO CHECK A RADIO RECEIVER SYSTEMATICALLY
WHAT TO DO IN THE CUSTOMER'S HOME
CHECK THE ANTENNA UPON ARRIVAL AT THE HOME
QUESTION THE OWNER AND CONDUCT A VISUAL EXAMINATION OF THE RECEIVER, ALSO NOTING THE MAKE AND MODEL NUMBER
CONDUCT A GENERAL CHECK-UP WITH THE TEST LAMP
REMOVE THE CHASSIS AND SPEAKER IF HOUSED IN A CONSOLE CABINET
CHECK THE TUBES
WHAT TO DO IN THE SHOP
CHECK THE LINE-CORD AND POWER SUPPLY SYSTEM
MEASURE VOLTAGES AT THE TUBE SOCKETS
CHECK SPEAKER AND A-F STAGES
CHECK THE DETECTOR
CHECK THE R-F AND I-F STAGES
CHECK THE MIXER OR CONVERTER STAGE
CHECK ALL SPECIAL SYSTEMS
CHECK PARTS, REPLACE DEFECTIVE PARTS, MAKE ALL NECESSARY ADJUSTMENTS AND CHECK PERFORMANCE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COOPERATION
SERVICE